

Using Microwave Facilities in Lower Manhattan

Introduction and Summary

The purpose of this section is to survey the current use of short-haul microwave in Manhattan, to assess the extent of microwave frequency congestion in Manhattan and to assess the likelihood that a typical business location can install a microwave link to gain access to an interexchange carrier point of presence (POP) or similar location.

Lower Manhattan, with the largest concentration of business activity in the country, almost certainly has the greatest use of short-haul microwave and the most spectrum congestion. However, for a number of reasons, we believe that it is feasible to connect almost any business location in Manhattan by microwave to an interexchange carrier POP. Moreover, we believe that it is also likely that most business customers can be connected via microwave to buildings served by the New York Teleport fiber optic cables.

First, for the short path lengths needed in lower Manhattan, the appropriate frequency bands are 18 GHz and 23 GHz since the FCC now restricts the use of other bands for longer paths. Only recently did the Federal Communications Commission (FCC) adopt technical specifications for these bands, and only recently has equipment become available. At these frequencies, there is as yet little or no congestion.

Second, the FCC regulatory scheme for microwave radio distinguishes between private users and common carriers. In the more mature (and more congested) frequency bands, the FCC usually allocated frequencies for either common carrier or private use. These exclusive allocations limited the ability of users to choose frequencies, particularly in a congested environment. However, both private users and common carriers as well as a new category of "private carriers" are eligible in the 18 GHz and 23 GHz bands.

Third, a review of 18 GHz and 23 GHz data, supplied by a frequency coordination contractor,⁴ shows large numbers of links that were coordinated, but not actually

⁴ Shooshan & Jackson Inc. commissioned a study of the 18 and 23 GHz frequencies by Comsearch in March 1987. The Comsearch study provided two outputs, a printed list of all licensed and coordinated radio links in lower Manhattan and map overlays which showed the specific microwave routes. The list of radio links was keyed into our computer for analysis and is reproduced as Appendix 2 to this report.

installed yet. This strongly suggests that these frequencies and paths are being "warehoused," and that they are in fact available for use when customer needs arise.

Fourth, review of the same data shows that local microwave carriers have established hub-and-spoke configurations with hubs located on tall buildings. Thus, even though microwave links require line-of-sight paths and can be blocked by intermediate buildings, these hubs have probably been chosen so that line-of-sight paths do actually exist to business locations in most cases.

In summary, it seems highly likely that local microwave can be used in lower Manhattan to connect to virtually any customer location.

FCC Microwave Regulatory Scheme

The FCC's scheme for regulating the use of microwave spectrum includes eligibility rules, permissible use rules, technical specifications and frequency coordination. These are discussed in turn.

Eligibility and Permissible Use

The eligibility rules are based on the idea that there are four types of users who use the microwave spectrum for different purposes and need different technical specifications. These four are common carriers (regulated by Part 21 of the FCC Rules); broadcasters (Part 74); cable TV operators (Part 78); and private commercial companies (Part 94). The eligibility rules are written so that, in principle, an entity is eligible in one and only one of these four services.

The FCC traditionally allocated spectrum to these four services on an exclusive basis. For example, common carriers and private users each have separate exclusive spectrum allocations at 2 and 6 GHz, and common carriers also have exclusive 4 GHz and 11 GHz spectrum.

However, in recent decisions the FCC has allocated spectrum on a shared basis. The FCC reasoned that it is not uncommon to have different patterns of usage between

The map overlays are oversize and do not reproduce well when reduced. Thus, they have been omitted from this report.

common carriers and private users, so that, for example, the common carrier spectrum in a particular area might be heavily congested while the private spectrum might be sparsely used. Thus, for 18 GHz and 23 GHz bands, the allocation is shared rather than exclusive. By allocating large bands on a shared basis rather than splitting up the bands into narrower, exclusive allocations, the FCC felt that there would be a higher likelihood of meeting user needs.

The permissible use rules are generally tied to the eligibility categories. For example, broadcasters are permitted to use the microwave spectrum listed in Part 74 to carry programs for broadcasting, but they are not permitted to use this spectrum for internal administrative traffic. Private companies are permitted to use Part 94 spectrum in support of their business operations, but not for broadcasting operations. (One significant exception to this is the 21.2-23.6 GHz band. Broadcasters are eligible to be licensed as private companies and are permitted to use this band to carry broadcast programming.) Nor is it permissible to offer a common carrier service on private microwave frequencies. However, a major change to the permissible use rules, discussed more fully below, now permits the use of private microwave spectrum for profit-making "private carrier" service.

Private Carrier Decision (FCC Docket No. 83-426)

Traditionally, the FCC allowed private microwave licensees to share their radio channels with other eligible users on a non-profit basis. In 1985, the FCC adopted a decision that permitted these licensees to sell excess capacity at a profit. In addition, the Commission created a new class of "private carriers" who are eligible for private microwave licenses and are permitted to sell capacity at a profit to anyone who would be eligible for a private microwave license.

The FCC expected that private carriers would be distinguished from common carriers in several ways. Private carriers would be likely to establish medium-to-long-term contractual relations with relatively stable clients, and would be likely to tailor their offerings based on the personal and operational compatibility of potential users with users already on the system. Moreover, these carriers would not hold themselves out to offer service without discrimination to the general public.

It is too soon to know whether the private carrier business will grow quickly or slowly. However, the FCC was influenced by the popularity of private carrier systems licensed in the private land mobile service since 1974.

With the availability of private microwave spectrum, as well as liberal eligibility and permissible use policies for the domestic satellite service, there is little reason for new start-up communications service vendors to become common carriers. Private carriers have a great deal more flexibility than common carriers and substantially less regulatory burden. Common carriers must publish their rates in the form of tariffs⁵, and must not discriminate between customers in the pricing of their services. Private carriers need not publish their rates, and can charge different prices to different customers for equivalent services.

Technical Standards

Technical standards are intended to protect against interference and promote the reuse of spectrum. Microwave technical standards include power limits, frequency stability, out-of-channel emission limits, minimum path lengths and antenna directivity.

Technical standards affect equipment costs as well as spectrum efficiency. Narrower channelizations or tighter frequency stabilities may permit more users to share a block of spectrum, but may also raise equipment costs so much that the users are forced to find cheaper alternatives or do without service altogether. Similarly, larger dish antennas focus the energy of the radio transmitter into a narrower geographical beam, allowing the same frequency to be reused at locations nearer to the original transmitter than might be the case with smaller dish antennas. Of course, larger antennas are more expensive (in some cases, much more expensive) than smaller antennas.

To discourage the use of lower frequencies for short-haul links, a minimum path length requirement was adopted. Because of propagation features of the atmosphere, lower frequencies are more useful for longer path lengths. By adopting minimum path length requirements, the FCC has sought to preserve these lower frequencies for longer path

⁵ Not all common carriers must file tariffs. The FCC now allows non-dominant carriers to refrain from filing tariffs.

requirements. The FCC favors the use of higher frequencies, above 10 GHz, for shorter paths. For most microwave paths of relevance to this study, the FCC minimum path length requirement virtually forces them to be at 18 GHz, 23 GHz or higher.

In general, the FCC's policy goals in adopting technical specifications are to ensure that the spectrum is used in a manner that is both technically and economically efficient, and to promote intensive use of the spectrum to meet user needs. These goals are seldom consistent with one another. Particularly at the higher frequencies (23 and 31 GHz) where technology is still evolving, the Commission has adopted less stringent technical specifications in order to keep equipment costs down and thereby promote the use of unused or lightly used spectrum.

Frequency Coordination

Frequency coordination is part of the licensing process. It is a technique used to enforce the principle that an earlier licensee should be protected from interference caused by a later licensee. In doing frequency coordination, an entity that wants to apply for a radio license will first check a data base of existing users to find a frequency or frequencies that do not interfere with, nor are subject to, interference from existing microwave links. Such data bases are maintained by commercial contractors such as Spectrum Planning, Inc. and Comsearch, Inc., as well as by AT&T and perhaps other carriers.

For common carrier microwave applications (and for private microwave users sharing frequencies with common carriers), the next step, after identifying interference-free frequencies, is to send a notice to other nearby users advising them of an intention to file a license application. This "prior coordination" is a process that is required by FCC Rules, but operated privately by commercial contractors rather than by the FCC.

A nearby user, who might disagree with the initial interference analysis and believe that his microwave link will be subject to interference, would at this point, respond with a letter disputing the coordination. Such disputes are not uncommon. The initial frequency and path selections are generally based on a computer analysis that may not have precisely included the effects of terrain shielding, so a field survey may yield more precise information about the shielding of the disputant's receiver. The applicant

and the disputant may have made different assumptions about the terrain or the technical features of the equipment.

If a dispute occurs, the standard practice is for the two parties to negotiate an agreement. This negotiated agreement may be as simple as a verbal agreement on assumptions in the calculations, or may require the new applicant to specify a different equipment configuration. The applicant can, for example, agree to install a larger (and more expensive) antenna to narrow the beam of the signal and thereby minimize interference in certain directions. In unusual situations, the applicant might agree to pay for the replacement of some of the receiving equipment in the disputant's network with equipment that is less susceptible to interference. In almost every instance, however, the dispute is settled at this stage in the process and the new applicant submits an application to the FCC with the certainty that no interference will result.

After prior coordination is completed, the applicant is able to file with the FCC. However, not all applicants actually file at this time. The frequency coordination contractors enter prior coordination data into their data bases on the assumption that the link will be installed. Thus, subsequent applicants must avoid frequencies and locations that might cause interference to links that are coordinated earlier, even if these earlier-coordinated links are not yet installed. It is at this point that speculators are able to tie up (or "warehouse") unused spectrum. As discussed more fully below, a review of data supplied by a frequency coordination contractor suggests that this has happened in Manhattan.

For private microwave applications on frequencies not shared with common carriers, the prior coordination process is not required. After the computer data base frequency selection, the application is submitted to the FCC and placed on public notice for 30 days. During the public notice period, any nearby licensee who believes that his network will be subject to interference can file a Petition to Deny. If this occurs, the FCC staff will not try to reach a decision; instead they will instruct the applicant and the petitioner to negotiate a settlement.

In practice, microwave frequency coordination and interference disputes are settled by negotiation between the new applicant and the prior licensee. In almost every instance, the two parties are able to agree on a route and frequency selection that will

meet the applicant's needs without causing interference to the earlier licensee. In some cases the mutually-acceptable choice might be more expensive than the original choice because it might require larger antennas or a different routing with intermediate repeaters.

General Background Regarding 18 and 23 GHz

The 18 GHz and 23 GHz bands were virtually unused until recently. According to the FCC, as of early 1982, there were only 159 licensed links in the 17.7-19.7 GHz band and only 36 in the 21.2-23.6 GHz band. (Notice of Inquiry in Gen. Docket No.82-334, released July 9, 1982, at Appendix G.) Yet, as of the fall of 1986, there were about 1,800-2,000 licensed at 18 GHz and about 3,600-4,000 licensed at 23 GHz according to informal information from the FCC staff.

The 18 GHz and 23 GHz bands are much larger than the microwave bands at lower frequencies. The 18 GHz band contains 2000 MHz of spectrum, and the 23 GHz band contains 2400 MHz. By comparison, the common carrier microwave bands at 4 GHz and 6 GHz each contain 500 MHz, and the 11 GHz band contains 1000 MHz. The 6 GHz private microwave band contains 350 MHz, and the former 12 GHz private microwave band, since reallocated for Direct Broadcast Satellite service, contains 500 MHz.

For these reasons, the 18 GHz and 23 GHz bands are relatively uncongested compared with lower frequency bands.

The 21.2-23.6 GHz Band

The 21.2-23.6 GHz band is allocated half for common carriers and half for private users. This entire band is also shared with the Federal Government, whose use is regulated by the Intergovernmental Radio Advisory Committee of the Department of Commerce. The FCC, in a 1980 decision, adopted technical specifications for the 21.8-22.0 and 23.0-23.2 GHz portions of the band; these two sub-bands 21.8-22.0 and 23.0-23.2 GHz are in the half allocated for private use. The FCC also adopted a channel plan consisting of 50 MHz channels for these sub-bands. The Commission rejected the proposal that portions of the 21.2-23.6 GHz band be available for unlicensed use or use without frequency coordination. However, as discussed below the FCC later decided that the 31.0-31.3 GHz band could be used without frequency coordination.

Although the 50 MHz channel plan was adopted only for the two sub-bands, it has become the *de facto* channel plan for the entire 21.2-23.6 GHz band. The FCC did not impose any spectral efficiency requirement (such as the 1 bit/sec/Hz requirement which exists at lower frequencies) for this band. Thus, a 50 MHz channel might carry a video channel, a 1.5 Mb/s signal, a 6 Mb/s signal, or perhaps only a 56 kb/s signal. This versatility in channel carriage as well as the modest technical requirements have resulted in low equipment costs for this band.

There is no single figure which explains well the enormous capacity of this microwave band. However, we can illustrate the capacity by calculating the capacity of a few hypothetical systems. First, let us try to calculate the maximum capacity between two points A and B. The 2,400 MHz of spectrum in the 23 GHz band supports 24 pairs of 50 MHz channels. If each channel pair were used to carry a DS2 signal then there would be a total capacity of $24 \times 96 = 2,304$ voice channels between A and B. However, this is an inefficient use of the radio spectrum. Radios are now available which transmit a DS3 signal in the 50 MHz channels. If each channel pair were used to carry a DS3 signal, there would be a total capacity of $24 \times 672 = 16,128$ voice circuits between A and B.

Additionally, a single channel can be used for multiple paths from a single point. Doing so requires sufficiently directional antennas to reject the otherwise interfering signal. Polarization discrimination can also be used to reduce interference. Such techniques are commonly used at lower frequencies, however the lack of congestion at 23 GHz has allowed us to escape the need for re-using a single channel at any one location. But, if we were to use each channel on three bearings (azimuths) then the capacity at 23 GHz of hub would be triple the numbers given above.

The 17.7-19.7 GHz Band

After a series of decisions resulting in a technically unsatisfactory channel plan for the 17.7-19.7 GHz band, the FCC finally adopted a consensus plan proposed by a number of interested manufacturers and trade associations. The final 18 GHz channel plan is discussed in the Attachment. In addition, a 1 bit/sec/Hz efficiency standard was adopted for the entire 17.7-19.7 GHz band effective December 1988.

The 18 GHz point-to-point spectrum can be used for any type of signal: analog telephony, digital data, video, etc. In practice, most of the use is digital at T-1 and T-3 rates. Typical users include common carriers and sophisticated private users such as electric utilities, petroleum companies and local governments. Broadcast and cable TV use is very small.

The 31 GHz Band

In early 1985, the FCC adopted regulations and technical specifications for the 31.0-31.3 GHz band. The most significant aspect of this decision is the absence of a frequency coordination requirement even though there is a license requirement. Consequently, applicants can save time in preparing their license applications, but they are not guaranteed interference-free operation as would be the case in bands requiring frequency coordination. Technical specifications are similar to the 23 GHz band, including 25 and 50 MHz channels and 0.03% frequency stability. Although a fairly stringent antenna directivity requirement was adopted initially, that requirement was lifted in a reconsideration decision. Any entity, including a private individual, is eligible to use this band.

For most fixed operations, the 21.2-23.6 GHz band appears preferable to the 31 GHz band since frequency coordination takes little time and assures interference protection. The one logical use for this band will be temporarily-fixed links installed by carriers for a quick response to user needs, either to meet a temporary requirement or for use while a permanent 23 GHz license is being processed. Carriers will apply for a blanket license to use this band, either within a specified geographical area or anywhere in the U.S. Within a few hours of a customer order, the carrier can have a link up and operating. Interference protection will be achieved by trial and error--turning on the receiver and listening for an interfering signal. The transmitters and receivers will be frequency agile--tunable to different channels--so that the user can avoid interference by turning to a different channel. No equipment is yet on the market for this frequency band, but we believe that at least one manufacturer has such a product under development.

Microwave Usage in Manhattan

Manhattan is an island about 12 miles long. However, a great majority of all commerce in Manhattan is conducted in the southern part of the island, south of

Central Park. The distance from the tip of Battery Park to the south end of Central Park is about five miles. For this reason, the short-haul 18 and 23 GHz bands are the frequency bands of interest.

Much of the discussion in this section is based upon information extracted from the frequency coordination data base for the 18 and 23 GHz bands for the Manhattan Island area supplied by Comsearch, Inc. The information in this listing includes one line of data for each link that has been frequency coordinated. The information for each link includes: transmitter location, direction of path, channels or frequencies coordinated, and applicant's name. A link may correspond to one or more channels operating along the same path.

In this listing, there are 345 links at 23 GHz and 502 links at 18 GHz. Considering the small geographical area covered and the relatively short period of time since these bands became available, this is a surprisingly large number of links.

Each link in the data base can represent one or more frequencies or channels. An analysis of the data shows that each 23 GHz link, on the average, represents 1.98 channels and each 18 GHz link, on the average, represents 3.32 channels. These are not large numbers, however, in view of the enormous amount of spectrum represented by these two bands and the large numbers of channels they contain. The 23 GHz channel plan includes 24 channels and the 18 GHz channel plan, which is very complicated, contains a total of 332 channels. (Note: many of these channels overlap; see Appendix 1 for a more detailed discussion of the 18 GHz channel plan). In fact, these links are only sparsely populated, with only a few of the possible channels listed on each link.

Coordinated but Unlicensed Microwave Paths in Manhattan

It appears that many of the links in the data base are coordinated but not licensed, because the file entry does not include an FCC-assigned call sign. Once a link is entered into the coordination data base, other later-coordinated links must avoid causing interference to the earlier-coordinated link. In practice, this is true even if the license application for the earlier-coordinated link is filed later at the FCC than the application for the later-coordinated link. The earlier-coordinated link must be avoided, even if a license application for that link is not filed for months or even

years. The earlier coordination allows an applicant to lock up frequencies and paths. to "warehouse" them, for long periods of time.

According to FCC policies, frequency coordination should be accomplished within six months prior to the filing of a license application. From the FCC's viewpoint, this minimizes the likelihood that interference could result because the data base became out of date. It also means that coordinations should be purged from data bases if no application is filed within six months. In practice, however, in order to take into account delays in designing complex networks, and in order to assure capacity for growth, coordinations can be renewed. Thus, coordinated links can remain in the data bases for long periods of time, and other applicants must design their networks to avoid these unbuilt links. This is a policy which works well in uncongested portions of the spectrum -- especially if the systems involved require significant planning or capital budgeting delays. Such warehousing will become inequitable or will fall apart under speculative strains if spectrum scarcity becomes a problem in the affected region of the spectrum.

A review of the Manhattan data base suggests that 490 links, or 58 percent of the total links listed in the Comsearch report are coordinated but not licensed. Thus, rather than showing that Manhattan is congested, the data base shows that Manhattan contains a very large number of microwave paths that have been frequency coordinated and are available, but not yet in use.

As discussed below, it is most apparent from the data base that Local Area Telecommunications Inc. (LOCATE) is coordinating large numbers of paths in Manhattan. Other carriers which have apparently done this (though to a far lesser extent), include New Jersey Bell Telephone, 3M Metropolitan Transmission Center, Satellite Gateway, U.S. Transmission Systems, Eastern Microwave, Inc. and MCI Telecommunications.

Thus, not only are the links in the data base sparsely populated with only a few of the possible channels listed, many of these links are not in use at all; they are merely coordinated for future use.

LOCATE: the Largest "Owner" of Coordinated Links in Manhattan

Local Area Telecommunications, Inc. (LOCATE) is a local communications carrier operating primarily in the New York City area. (Other local microwave carriers in Manhattan include Waterfront Communications Corporation, 3M Metropolitan Transmission Center, Private Satellite Network, Wold Communications and Satellite Gateway.) LOCATE has far and away the largest number of microwave links in the data base, with 319 links out of a total of 847. By comparison, no other entity has more than 22 links listed. The largest listings are shown below.

<u>Licensee</u>	<u>Number of Links</u>			
	<u>Total</u>	<u>Licensed</u>	<u>Coord.</u>	<u>Rx Only</u>
LOCATE	319	86	233	0
U.S. Transmission Systems Inc.	22	9	13	0
Chase Manhattan Bank (private network)	20	10	10	0
Private Satellite Network	20	6	11	3
AT&T Communications	18	9	9	0
MCI Telecommunications	21	16	5	0
Todd Communications, Systems Inc.	18	9	0	9
3M Metropolitan Transmission	16	6	10	0
Port Authority of NY and NJ	16	10	0	6
New Jersey Bell Telephone	14	9	5	0
Others	421	187	194	40
=====				
Total	905	357	490	58

Of the 319 links listed for LOCATE, 86 are licensed and the remaining 233 are merely coordinated.

As a carrier, LOCATE stands ready and willing to supply communications channels to users within the New York City area. Their market officials were not willing to admit, in a telephone conversation, that they are "warehousing" frequencies. However, they did say that they have coordinated a number of links between buildings where they expect that they might be asked to supply service, and that they would be happy to install equipment and supply service upon request.

For a description of some of LOCATE's business activities see the article DTS: A Logical First/Last Mile Choice, in the October 1986 issue of Telecommunications at page 65. The article describes LOCATE's use of DTS radio to serve low capacity links

and gives some general discussion of LOCATE as well. The article was written by Jeremiah K. Rehse who is described as vice-president of engineering of LOCATE.

Local Microwave Network Hub and Spoke Configuration

A review of the data base shows that many of the carriers operate local networks that have a hub and spoke configuration. For example, from 215 Lexington Avenue, Private Satellite Network has links emanating at bearings of 126.1, 178.3, 183.0, 211.9 and 212.5 degrees. From 55 Water Street, LOCATE has links emanating at bearings of 20.2, 90.0, 148.0, 159.2, 160.9, 165.0 and 345.0 degrees. From 1633 Broadway, MCI has links emanating at bearings of 32.9, 128.3, 213.1 and 273.5 degrees. From the World Trade Center, LOCATE has links emanating at bearings of 20.3, 31.7, 33.5, 51.5, 138.7, 159.2, 180.0 and 293.1 degrees. AT&T Communications appears to use two hubs, New York 4 (32 Avenue of the Americas) and New York 7 (811 Tenth Avenue), with three links emanating from each.

Hub and spoke configurations for local networks make sense from economic, technical and operational perspectives. The hub provides a control center for dispatching and trouble-shooting. It is a place where traffic can be combined or concentrated with multiplexing equipment. It provides a convenient point of connection with long-haul carriers by means of high capacity microwave or a co-located satellite earth station.

Terrain and Building Blockage

Microwave links require line-of-sight paths. Unlike radio services operating at other frequencies, microwave signals cannot bend around obstructions. In the Western United States, mountains block microwave paths. In Manhattan, tall buildings have the same effect.

It is not possible to provide a precise assessment of the impact of building blockage in Manhattan. Every path is different and must be analyzed individually. However, in general, it seems likely that a high proportion of links can be implemented, for two reasons.

First, as mentioned above, a number of the local microwave carriers seem to have adopted a multiple hub and spoke configuration for their networks. The hubs are located where they might be expected: tall buildings, such as the World Trade Center

and Empire State Building, that dominate the panorama. Chances are good that an unblocked path can be cleared from the rooftop of the customer's building to one of the tall hub roof-tops in Manhattan. Should a customer need a link between two private business locations, a double-hop with the hub as an intermediate repeater is a likely configuration. The local microwave carriers have undoubtedly installed high-capacity microwave links from their hubs to interexchange carriers, or may even be co-located with them, in order to meet customer needs for such interconnection.

In addition, it is possible to use passive repeaters in microwave paths to change the direction of the beam. A passive repeater is simply two antennas connected back-to-back. One antenna receives the incoming beam and the other antenna redirects it in another direction without adding any amplification. It is common practice to use passive repeaters to bend a microwave beam around a building that blocks a straight line-of-sight shot.

Connections to AT&T Points of Presence

AT&T has established six POPs in New York City, four of which are located in Manhattan. Of these four, the data base reveals that three are the locations of short-haul microwave transmitters:

<u>Location</u>	<u>Number of Transmitters</u>
32 Avenue of the Americas	4 AT&T, 5 LOCATE
33 Thomas Street	4 AT&T, 2 LOCATE
811 10th Avenue	4 AT&T, 2 LOCATE

We thus conclude that AT&T has at least begun testing, and perhaps providing, service over short-haul microwave between its POPs and customer locations.

Connections to the Teleport Communications Optical Fiber

A review of the data base shows that the following locations on the Teleport Communications fiber optic cable are also locations of short-haul microwave transmitters:

<u>Location</u>	<u>Number of Transmitters</u>
World Trade Center	56
Empire State Building	28
60 Hudson Street	2 (Satellite Gateway, Eastern MW)
60 Broad Street	4 (LOCATE)
5 Penn Plaza	4 (LOCATE)
399 Park Avenue	1 (Citicorp Satellite Comm.)

From this we conclude that short-haul microwave is readily available to connect customers into the Teleport fiber optic cable at the two hubs--the World Trade Center and the Empire State Building--and may also be available for interconnection at other Teleport locations.

Microwave Health and Safety

One potential drawback to the use of local microwave interconnection links is that some people claim that the radio frequency energy emitted by microwave transmitters could be dangerous to humans. If so, then authorities might establish regulations that constrain or prohibit the use of microwave transmitters in populated areas.

Government agencies have been reviewing scientific evidence of harm for a number of years and have generally concluded that point-to-point microwave transmitters have little or no likelihood of causing harm to the general public. This is because of the low power that is emitted (generally less than 10 watts, but less than 1 watt at 18 GHz and 23 GHz) and the inaccessible locations of microwave transmitters atop towers and roofs. (However, there may be a point near the feed horn of the microwave dish where the power level is high enough to cause localized heating of the body. Thus, workmen must avoid these locations and repair on microwave dishes should be conducted only when the transmitter is turned off).

Because of the possibility of harm to the public from some high power radio transmitters, the FCC in 1985 adopted a policy that required radio transmitters to comply with special license processing guidelines dealing with environmental RF concerns. However, because of the low power of microwave transmitters, the FCC proposed to categorically exclude them from these requirements.

The U.S. Environmental Protection Agency is in the process of adopting safety standards for radio emission levels. While some broadcast stations, which transmit hundreds of thousands or even millions of watts, might need to be modified to meet the EPA proposed standards, microwave transmitters fall well below the levels of concern. Some state and/or local governments have adopted or proposed radio frequency safety standards; standards which have been at about the same levels as the EPA is proposing to adopt.

Microwave Cost Model

Radios:

DS1 and DS2 rate: \$22,000 (two radios, one link)
Product: NEC 18G6MB
Range: Up to five miles
If range greater than five miles and less than seven add \$1,600 for higher gain antennas
Installation and Licencing: \$9,000
Data Source: Phone call NEC America, April 15, 1987
NOTE: This radio contains an integral M12 multiplexer so it interfaces directly at the DS1 rate even though it transmits at the DS2 rate.

DS3 Rate: \$90,000 (two radios, one link)
Product: Digital Microwave Corporation DMC 18
Range: Up to five miles
If range greater than five miles and less than 10 add \$2,400 for higher gain antennas.

Operations and Maintenance costs:

A site rental or roof access charge allowance of \$2,000 per year is included.

If a repeater site is required (double-hop configuration) add another \$2,000 per year for site rental.

* A O&M allowance of one percent per month of the hardware cost is included.

Conclusion

While there is substantial use of the 18 GHz and 23 GHz frequencies in Manhattan, the use is small compared to the total capacity of the band. Although the data base appears to show a large number of links, few of the links have been implemented and few channels on those links are actually being used. These two bands have an enormous capacity compared with lower frequency bands.

Line-of-sight paths are probably available to a large proportion of office buildings in lower Manhattan because of the hub and spoke configuration of local microwave networks. Even when the line-of-sight path is blocked by an intermediate building, it is common practice to use passive repeaters to bend the microwave beam around these obstructions.

For these reasons, we conclude that there is a very high likelihood of interconnecting any business location in lower Manhattan with a POP of an interexchange carrier or to a point of connection with the Teleport optical fiber using local microwave.

Converting Fixed Costs into Monthly Costs

Method

For each technology, four different quantities are estimated:

1. Capital costs
2. Monthly operating and maintenance costs
3. Relevant service life
4. Salvage value at the end of the estimated service life

The monthly cost for the system (or subsystem) is then given by

$$M + (C - (S / (1 + r)^n)) (r / (1 - (1 / (1 + r)^n))) ,$$

where C is the original capital cost,

M is the monthly operating and maintenance cost,

n is the relevant service life (in months),

S is the salvage value, and

r is the interest rate (percent per month).

Discussion

The cost methodology employed in this analysis has the following primary strengths:

- o Calculation of monthly cost indices
- o Ranking of system costs according to net present value analysis (if service lives are equal)

It satisfies four essential criteria:

- o The monthly charge should be a single number (rather than varying from month to month).
- o The monthly charge should reflect the cost of capital.
- o The monthly charge should reflect capital recovery.
- o The monthly charge should reflect any salvage value.

This monthly capital recovery cost calculation is identical to the annuity payments required for an annuity with purchase price equal to the original capital cost, term equal to the service life, with a lump payment at the end of the term equal to the salvage value, and calculated using the same interest rate. This calculation of the monthly capital recovery cost is similar to the calculation of the payments in a full payback (financial) lease or to a consumer loan.

This cost methodology ignores tax effects and looks only at budgetary costs. Several reasons justify ignoring tax effects. First, tax effects are usually a second order effect. They might change the cost of a microwave or fiber optic system 10 or 20 percent but not 80 percent. Second, generally speaking, we do not know the tax position of the user. Some large users (e.g., universities, state governments) are not taxpayers. Even large customers who are taxpayers have widely differing marginal tax rates. Third, including tax effects (such as accelerated depreciation) would only lower the effective cost of a system. Thus, ignoring tax effects makes our results more conservative; i.e., underestimating the economic attractiveness of such systems.

The cost calculations described below used this method to calculate the monthly costs of microwave and fiber optic systems. A lifetime of seven years with no salvage value was assumed. The cost of capital was set at a conservative 15 percent to reflect a relatively high corporate hurdle rate.

Microwave and Fiber Facility Costs in Lower Manhattan

The tables below show the costs of alternative high-capacity telecommunications facilities in Manhattan.

Table 1 shows the monthly costs of fiber optic systems spanning distances from 0.1 to 15 miles. The table is broken down into two parts. Table 1A shows the costs assuming that building entrance requires no special construction. Table 1B shows the effects of adding a \$7,500 entrance construction cost to the system cost.

Table 2 shows the monthly cost of alternative microwave systems. Table 2A shows the cost of single-hop microwave systems, while Table 2B shows the cost of double-hop, active-repeater systems.

Tables 3 through 6 show the first cost and the monthly operating costs (exclusive of capital costs) for the technologies considered in Tables 1 and 2. These tables allow the reader to substitute his or her own assumptions for equipment lifetime, cost of capital, and salvage value in calculating the equivalent monthly capital costs.

TABLE 1A
Total Monthly Costs of Fiber Optic Installation With Easy Access to Ducts *
(Seven Year Life, No Salvage Value, 15% Cost of Capital)

DISTANCE	0.1	0.5	1	1.5	2	3	4	5	7	10	15
DS-1	134	510	980	1451	1921	2861	3801	6265	8204	11112	15960
DS-2	170	688	1336	1984	2632	4049	5296	6265	8204	11112	15960
DS-3	1515	1903	2387	2872	3357	4326	5296	6265	8204	11112	15960

TABLE 1B
Total Monthly Costs of Fiber Optic Installation With Difficult Access to Ducts *
(Seven Year Life, No Salvage Value, 15% Cost of Capital)

DISTANCE	0.1	0.5	1	1.5	2	3	4	5	7	10	15
DS-1	279	655	1125	1595	2065	3005	3945	6410	8349	11257	16104
DS-2	315	833	1481	2129	2777	4194	5440	6410	8349	11257	16104
DS-3	1660	2047	2532	3017	3502	4471	5440	6410	8349	11257	16104

* Easy access to ducts assumes no cost of entrance to the ducts from the building location. Difficult access assumes entrance to ducts is not readily available from the building location, and that gaining access is costly.

TABLE 2A
Total Monthly Costs of Microwave Radio (Single Hop)
(Seven Year Life, No Salvage Value, 15% Cost of Capital)

DISTANCE	0.1	0.5	1	1.5	2	3	4	5	7	10
DS-1 (NEC 10G6MB)	985	985	985	985	985	985	985	1032	1032	
DS-2 (NEC 10G6MB)	985	985	985	985	985	985	985	1032	1032	
DS-3 (DMC 18)	2977	2977	2977	2977	2977	2977	2977	3047	3047	3047

TABLE 20
Total Monthly Costs of Microwave Radio (Double Hop)
(Seven Year Life, No Salvage Value, 15% Cost of Capital)

[illegible]

TABLE 3A
First Cost of Fiber Optic Installation with Easy Access to Ducts

DISTANCE	0.1	0.5	1	1.5	2	3	4	5	7	10	15
DS-1	2357	6271	11164	16058	20951	30737	40523	103554	125616	158709	213863
DS-2	4020	14587	27796	41004	54213	84765	92523	103554	125616	158709	213863
DS-3	49503	53915	59431	64946	70462	81493	92523	103554	125616	158709	213863

TABLE 3B
First Cost of Fiber Optic Installation with Difficult Access to Ducts

DISTANCE	0.1	0.5	1	1.5	2	3	4	5	7	10	15
DS-1	9857	13771	18664	23558	28451	38237	48023	111054	133116	166209	221363
DS-2	11520	22087	35296	48504	61713	92265	100023	111054	133116	166209	221363
DS-3	57003	61415	66931	72446	77962	88993	100023	111054	133116	166209	221363

* Easy access to ducts assumes no cost of entrance to the ducts from the building location. Difficult access assumes entrance to ducts is not readily available from the building location, and that gaining access is costly.

TABLE 4A
Monthly Operating, Maintenance & Right-of Way Costs of Fiber Optic Installation with Easy Access to Ducts

DISTANCE	0.1	0.5	1	1.5	2	3	4	5	7	10	15
DS-1	89	389	765	1141	1516	2268	3019	4267	5780	8050	11833
DS-2	92	407	800	1193	1586	2414	3510	4267	5780	8050	11833
DS-3	560	862	1241	1619	1997	2754	3510	4267	5780	8050	11833

TABLE 4B
Monthly Operating, Maintenance & Right-of Way Costs of Fiber Optic Installation with Difficult Access to Ducts

DISTANCE	0.1	0.5	1	1.5	2	3	4	5	7	10	15
DS-1	89	389	765	1141	1516	2268	3019	4267	5780	8050	11833
DS-2	92	407	800	1193	1586	2414	3510	4267	5780	8050	11833
DS-3	560	862	1241	1619	1997	2754	3510	4267	5780	8050	11833

* Easy access to ducts assumes no cost of entrance to the ducts from the building location. Difficult access assumes entrance to ducts is not readily available from the building location, and that gaining access is costly.

First Costs for Microwave Radio (Single Hop)

DISTANCE	0.1	0.5	1	1.5	2	3	4	5	7	10
DS-1 (NEC 18G64MB)	31000	31000	31000	31000	31000	31000	31000	32600	32600	
DS-2 (NEC 18G64MB)	31000	31000	31000	31000	31000	31000	31000	32600	32600	
DS-3 (DMC 18)	99000	99000	99000	99000	99000	99000	99000	101400	101400	101400

TABLE 5B
First Costs for Microwave Radio (Double Hop)

[illegible]

TABLE 6A
Monthly Operating, Maintenance & Right-of-Way Costs for Microwave Radio (Single Hop)

DISTANCE	0.1	0.5	1	1.5	2	3	4	5	7	10
DS-1 (WEC 18G6MB)	387	387	387	387	387	387	387	403	403	
DS-2 (WEC 18G6MB)	387	387	387	387	387	387	387	403	403	
DS-3 (DMC 18)	1067	1067	1067	1067	1067	1067	1067	1091	1091	1091

TABLE 6B
Monthly Operating, Maintenance & Right-of-Way Costs for Microwave Radio (Double Hop)

[illegible]